INDOOR AIR QUALITY ASSESSMENT

Atherton Hough Elementary School
1984 Sea Street
Quincy, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Atherton Hough Elementary School, 1984 Sea Street, Quincy, Massachusetts. Concerns about poor indoor air quality prompted the request.

On December 11, 2002, a visit was made to this school by Cory Holmes, an Environmental Analyst in the Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Cindy DeCristofaro of the Quincy Health Department and Kenny Olson, Senior Custodian. Andrew Scheele, Health Commissioner, Quincy Health Department and Dorothy Greene, School Principal were present for portions of the assessment.

The school is a two-story brick structure with occupied basement. The original school building was constructed in 1911. Additions were built in 1929 and in 1949. The school is made up of general classrooms, a cafeteria/auditorium, an art room, a daycare facility and a neighborhood dental clinic, which is located in the basement. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

The school has a kindergarten through fifth grade student population of 264 and a staff of approximately 35. The tests were taken during normal operations at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million of air (ppm) in seven out of thirty-two areas surveyed, indicating a ventilation problem in some areas of the building. Some portions of the ventilation system were not operating during the evaluation, which can limit airflow leading to increased carbon dioxide levels.

As discussed previously the school is comprised of three sections, each outfitted with different types of ventilation systems. Due to the complexity of the building's ventilation systems, this section is divided into three sub-sections.

Original 1911 Building

Fresh air is provided by an air handling unit (AHU) located in a large room on the ground floor that is connected to ductwork leading to air diffusers (see Picture 1). Fresh air is drawn into the building through a louvered vent in the basement (see Picture 2). Air is drawn through heating elements into a fan unit that distributes the air via wall mounted fresh air grilles in classrooms (see Picture 3). Classroom fresh air supply grilles are connected to the fan unit by ductwork located in the basement.

Pressurization created by the fresh air supply system provides classroom exhaust ventilation. Each classroom contains an exhaust vent located at floor level that is connected by ventilation shafts to the basement heating elements. A number of these vents were obstructed by cabinets, bookcases and other items; some were intentionally sealed to prevent backdrafting (see Tables/Picture 4). As the heating elements draw air into the ducts, return air is drawn from the basement exhaust ventilation shafts. Negative pressure is created in these shafts, which in turn draw air into the exhaust vents of each classroom. The draw of air into these vents is controlled by a draw chain pulley system in classrooms and pneumatically controlled louvers at the exit of rooftop exhaust shafts (see Picture 5). This system was either deactivated or inoperable in certain areas. The exhaust/chimney cap pneumatic louver system in Picture 6 had been removed, leaving the chimney cap open to the elements (see **Other Concerns** section of this report).

In addition, many of the control mechanisms for the natural ventilation system are either not operable or are missing (i.e., pull chains and louvers). Since the system is still in operation, the control mechanisms should be restored. Without a fully functional ventilation system, environmental pollutants can build up in the indoor environment and lead to poor air quality/comfort complaints.

1929 Wing

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 7). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (see Picture 8) and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located on the front of the unit. Univents were found deactivated in a few areas, which prevents a continuous source of outside air to provide ventilation. Obstructions to airflow, such as paper and boxes stored on univent air diffusers and desks in front of univent return vents, were also noted in classrooms (see Picture 9). In order for univents to provide fresh air as designed, univent air diffusers and return vents must remain free of obstructions. Importantly, these units must remain activated while classrooms are occupied.

Exhaust ventilation is provided by a mechanical system, which draws air into an ungrated hole, located at floor level in classrooms. Airflow is controlled by a flue located inside the duct. This system appeared to be off in some classrooms surveyed. In addition, these ungrated holes were being used to store recycling bins, crates, books, boxes and files in a number of areas (see Picture 10). As with the univents, in order for exhaust ventilation to function as designed, exhaust fans must be activated and remain free of obstructions.

1949 Addition

Fresh air for classrooms in the 1949 addition is also supplied by a univent system. Univents were found deactivated and or obstructed in several areas. The mechanical exhaust ventilation system in classrooms in this wing consists of grated, wall-mounted exhaust vents powered by rooftop motors. A number of exhaust vents were also obstructed by tables, chairs, boxes and other items.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). Please note that some of the ventilation systems, in their condition at the time of the assessment, cannot be balanced.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings ranged from 69^{o} F to 82^{o} F, which were above and slightly below the BEHA recommended comfort guidelines in several areas during the assessment. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. A number of temperature control/comfort complaints were expressed throughout the building; drafts were reported around the univent in classroom 15. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is difficult in an old building without fully functioning ventilation systems.

The relative humidity ranged from 19 to 40 percent, which was below the BEHA recommended comfort range in most of the areas surveyed. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water damaged wall plaster and efflorescence (i.e., mineral deposits) were observed in a few areas (see Picture 11), which indicates a current or historic water penetration problem. Efflorescence is a characteristic sign of water intrusion. As moisture penetrates and works its way through mortar around brick it leaves behind these characteristic mineral deposits. This condition indicates that water from the exterior is penetrating into the building.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Spaces between the sink countertop and backsplash were noted in classroom 16. Improper drainage or sink overflow could lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Unless functioning properly, the ventilation system can serve as a pathway for particulates and odors to migrate between areas of the building. The open shaft on the roof is a potential pathway for moisture, particulates and pests to enter the building.

A number of classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs) (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999). Dry erase board markers and cleaners contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

In an effort to reduce noise from sliding chairs, tennis balls are sliced open and placed on chair legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and to off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix II (NIOSH, 1998).

The teacher's workroom contained a lamination machine, two photocopiers, three mimeograph machines and several containers of duplicating fluid. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). It was reported by Mr. Olson that a work order had been submitted to provide local exhaust ventilation for this area.

Although no complaints of vehicle exhaust odors have been reported to MDPH in relation to the building, the potential for entrainment exists. Picture 12 illustrates the close proximity of the employee parking lot to the building and the potential for vehicle exhaust to be pulled into the univent fresh air intakes (called entrainment). Idling vehicles can result in the entrainment of vehicle exhaust into the building, which may, in turn, provide opportunities for exposure to compounds such as carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1996).

Conclusions/Recommendations

As discussed, with a number of the components of the school's ventilation system not fully functional, normally occurring environmental pollutants can build-up and lead to indoor air quality/comfort complaints. In view of the findings at the time of this visit, the following recommendations are made:

1. Based on the age, condition and availability of parts for ventilation components, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation systems throughout the building.

2. Repair/replace the chimney cap on the roof to prevent entry of pests, moisture, particulates and drafts. Cover the open cap in the meantime with wire mesh (chicken wire) to prevent entry.
3. Repair/replace thermostats and control mechanisms (e.g. pull chains, louvers) for ventilation system where needed.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. To maximize air exchange, the BEHA recommends that all ventilation systems that are operable throughout the building (e.g., gym, cafeteria, classrooms) operate continuously during periods of school occupancy independent of thermostat control.
6. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Keep plants away from the air stream of univents.
7. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water-damage and mold/mildew growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed. Consider replacing with one-piece, molded countertop.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

9. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.
10. Continue with plans to install local exhaust ventilation in photocopier room.
11. Seal around univent in classroom 15 to prevent drafts.
12. Consider relocating employee parking from areas in close proximity to air intake vents. If not feasible, post signs in parking area instructing employees not to back in to avoid entrainment of vehicle exhaust to remind them of Massachusetts anti-idling laws (MGL, 1996).
13. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
14. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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Picture 1

Large Fan Supplying Mechanical Ventilation System in 1911 Wing

Picture 2

Fresh Air Intake

Picture 3

Supply Air Vent in Classroom

Picture 4

Obstructed Exhaust Vent in Classroom

Picture 5

Pneumatically Controlled Exhaust Louvers on Rooftop Ventilation Shaft

Picture 6

Chimney Capped Removed From Ventilation Shaft

Picture 7

Classroom Univent

Picture 8

Covered Air Intake for Classroom Univent

Picture 9

Various Items Obstructing Airflow of Classroom Univent

Picture 10

Exhaust Cubby in Classroom, Note Materials Stored Within

Picture 11

Efflorescence Peeling Paint in Classroom

Picture 12

Vehicles Parked near Fresh Air Intake

TABLE 1

Indoor Air Test Results – Atherton Hough Elementary School, Quincy, MA December 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
(Outside) Background	420	36	38					Weather cold, westerly winds 5-10 MPH, overcast and cold
Gym (right side heating unit)								No fresh air – work order in for repair Thermostat not working
Gym (left side heating unit)								Thermostat not working
Basement Day Care Music Room	734	77	22	1	Y	N	N	Door open
W-Daycare	880	82	19	2	Y	N	N	
Gym/Auditorium/Cafeteria	690	74	19	$\geq$ 55	Y	Y	Y	Poor temperature control Supply not operable
Kitchen (off Gym)	1960	74	23	0	N	N	N	No working ventilation Door open
Speech/Hearing	3400	77	28	4	Y	N	N	
Room 1	1081	78	23	18	Y	Y	Y	Exhaust blocked not working, plants Computer monitors, window frame – water damage
Room 2	900	79	24	24	Y	Y	Y	Exhaust sealed

*** ppm = parts per million parts of air**
UV = Univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred	(1 Story – Red Brick)
	600 - 800 ppm = acceptable	
	> 800 ppm = indicative of ventilation problems	
Temperature -	70 - 78 °F	
Relative Humidity -	40 - 60%	

TABLE 2

Indoor Air Test Results – Atherton Hough Elementary School, Quincy, MA **December 11, 2002**

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 10	668	80	22	0	Y	Y	Y	Exhaust sealed, perimeter heat 8 computer terminals
Room 12 Vacant	510	72	28	≥ 16	Y	Y	Y	Exhaust closed due to heat Occupants gone 20 min
Rooftop								Chimney chase cap off Chicken wire – loose 1 open
Room 12 Occupied	789	69	39	16	Y	Y	Y	Exhaust closed
Room 20	969	70	40	23	Y	Y	Y	Window open Exhaust blocked/closed
Room 11	760	72	34	16	Y	Y	Y	4 computer monitors Exhaust shut and blocked
Room 21	740	73	32	14	Y	Y	Y	Exhaust blocked Plants
School Psychology	632	75	32	0	Y	N	N	Radiator
Principal's Inner Office	470	78	23	0	Y	N	N	
Principal's Outer Office	570	78	24	1	N	N	N	Door open 2 computers

*** ppm = parts per million parts of air**
UV = Univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred	(1 Story – Red Brick)
	600 - 800 ppm = acceptable	
	> 800 ppm = indicative of ventilation problems	
Temperature -	70 - 78 °F	
Relative Humidity -	40 - 60%	

TABLE 3

Indoor Air Test Results – Atherton Hough Elementary School, Quincy, MA December 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 16	465	72	22	0	Y	Y	Y	Exhaust – pull chain, sink caulking Supply off
Room 16	643	72	25	9	Y	Y	Y	Supply on, 5 computer monitors Exhaust closed, door open, pull chain
Room 17	750	74	26	18	Y	Y	Y	Supply on Exhaust partially blocked
Room 15	585	72	24	0	Y	Y	Y	Supply off and blocked Exhaust blocked, plants, drafty UV
Room 18 Computer Lab	480	71	25	0	Y	Y	Y	Supply on, chair in front of cubby 2 computer monitors
Room 19 Art Room	550	73	25	0	Y	Y	Y	Supply on Exhaust blocked, fan on, plants
Boys Room				0	Y			Supply on Exhaust blocked, carpeting
O T	600	70	28	0	Y	N	N	
Girls Room					Y	N	Y	
Room 9	655	80	22	0	Y	Y	Y	Exhaust not working – blocked w/ easel, blackboard 7 computer monitors

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UV = Univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred	(1 Story – Red Brick)
	600 - 800 ppm = acceptable	
	> 800 ppm = indicative of ventilation problems	
Temperature -	70 - 78 °F	
Relative Humidity -	40 - 60%	

TABLE 4

Indoor Air Test Results – Atherton Hough Elementary School, Quincy, MA December 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
1st Floor Girls Room				0	Y	N	Y	Sealed floor drain 6 stalls/2 adult
Guidance Office	996	79	24	1	Y	N	N	
Media Office	760	79	22	1	N	N	N	Laminator, Xerox, laser print Work order in for ventilator
Nursing Office	799	78	22	1	N	N	N	Hepa filter
Boys Room				0	Y	N	N	Cleaning supplies
Room 8	571	76	21	0	Y	Y	Y	Not working properly (deactivated w/ switch) reheat
Room 3	625	77	23	5	Y	Y	Y	
Room 4	586	76	22	5	Y	Y	Y	Supply on Exhaust blocked w/ supplies
Room 7	716	77	24	17	Y	Y	Y	Supply on and blocked, tennis balls-chairs, exhaust blocked w/ items
Room 5	436	74	23	1	Y	Y	Y	Window open, 15 pp usually, plants Supply off, blocked, exhaust partially blocked

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Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

(1 Story – Red Brick)